Supplemental Material

Appendix A

Day: One
Activity: Mini Challenge

Student Name: _____
School Name: _____

Objectives:

- Observe the real-world example of shipping.
- Discover how shipping companies win contracts.
- Explore how things float in water.
- Estimate the density of objects.

Recognize, Recall, & Reflect

What did you observe from the STEM Challenge Welcome that was interesting? Write 2 things.

_____
_____
_____

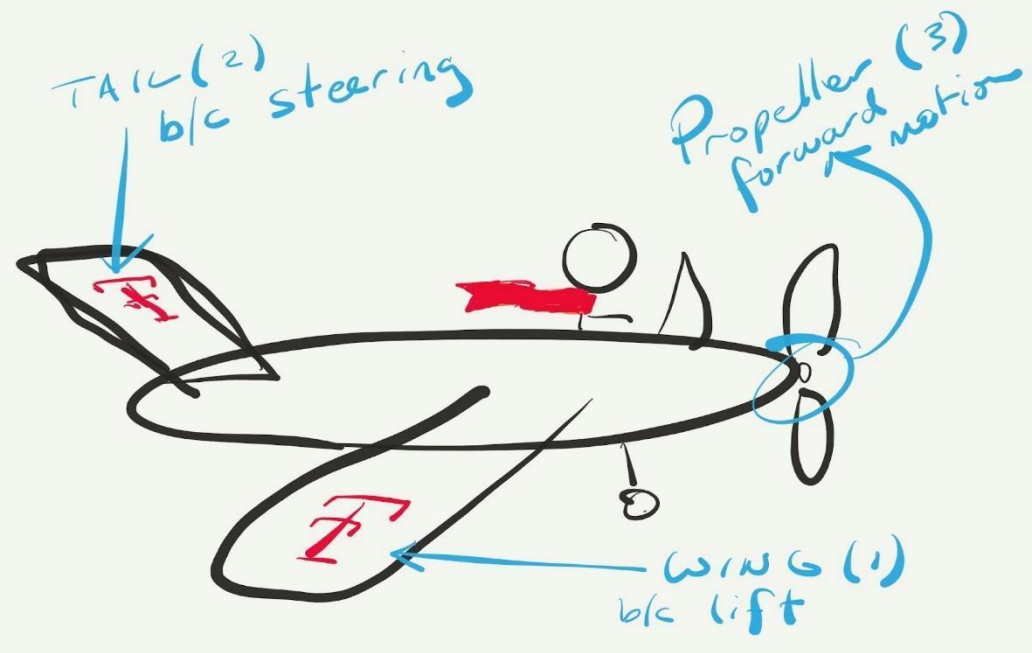
Table 1.1. ***Write down your own thinking about the advantages and disadvantages of each of the following two strategies for building your team's boat.***

Strategies	Advantages	Disadvantages
I want our team to have the lowest cost bid to make sure the job gets done		
I want our team to have a higher cost bid and make sure the job gets done the fastest		

Think Before You Do

Draw your idea of what a boat looks like. Consider how a boat floats in water.

Point out 3 things in your picture that make your boat <u>idea</u> effective for completing the challenge.
Rank those three things in importance by placing a 1, 2, and 3, next to it.
If you need help, see the ranking on the drawing of this airplane on the next page:



<u>Observe & Report</u>
You will be given a plastic wading pool with various objects that could potentially be used to make boats. Your observation activity is to figure out which objects float in water. Before you get started, make a prediction if each object will or will not float in Columns A and B of Table 1.2. Next, test each object in the wading pool. Observe if it floated or did not float and record your response in Column C.

Table 1.2*. Which do you think will float?*

Material	**<u>Predict</u>** **Column A:** Place a check here if it floats	**<u>Predict</u>** **Column B:** Place a check here if it won't float	**<u>Test</u>** **Column C:** Did it float or did not float?
10 cm x 10 cm square of cardboard			
Ball of tin foil (from a 10 cm x 10 cm sheet)			
Standard wooden popsicle stick			

Ball of duct tape (from 50 cm length)			
Penny (or other metal coin)			
PVC pipe (5 cm with 1 inch diameter)			
Cardboard with a 500 ml water bottle for weight			

Did any of the objects surprise you?

_____

Formulate & Create

A key to the challenge for this week is keeping your boat afloat. The way that large ships are able to float in the ocean (and ice floats in your drink) is due to *density*.

Density is a measurement that compares the amount of matter an object has to its volume. You calculate density by taking an object's mass and dividing it by its volume. If an object is heavy and compact, it has a high **density,** such as 11 grams per cubic centimeter. If an object is light and takes up a lot of space, it has a low **density,** such as 0.5 gram per cubic centimeter**. *You will want to create a boat design and build for low average density.***

Density = Mass / Volume

Now, based on your testing and observations, rank each item from least (1) to most (7) dense in Table 1.3. First, individually rank the materials in this order. Once each member of your team has ranked the items, discuss your density ranking with the rest of your team. Once your team has reached a consensus on ranking your items, submit your final rankings on the next sheet. **The team(s) with the most correct rankings will win additional funding to support their boat construction project!**

Table 1.3. *Density Ranking of Materials*

Material	Density Rank
• 10 cm x 10 cm square of cardboard	
• Ball of tin foil (from a 10 cm x 10 cm sheet)	
• Standard wooden popsicle stick	
• Ball of duct tape (from 50 cm length)	

• Penny (or other metal coin)	
• PVC pipe (5 cm with 1 inch diameter)	
• Cardboard with a 500 ml water bottle for weight	

Table 1.4. ***Team Consensus Density Ranking of Materials***

Material	Density Rank
• 10 cm x 10 cm square of cardboard	
• Ball of tin foil (from a 10 cm x 10 cm sheet)	
• Standard wooden popsicle stick	
• Ball of duct tape (from 50 cm length)	
• Penny (or other metal coin)	
• PVC pipe (5 cm with 1 inch diameter)	
• Cardboard with a 500 ml water bottle for weight	

Once you have finished, check your results with your teacher.

- 5 or More Items Ranked Correctly: 1,000.00 units
- 4 or Less Items Ranked Correctly: 0.00 units

Appendix B

Day: One
Activity: Design Challenge

Student Name: _____
School Name: _____

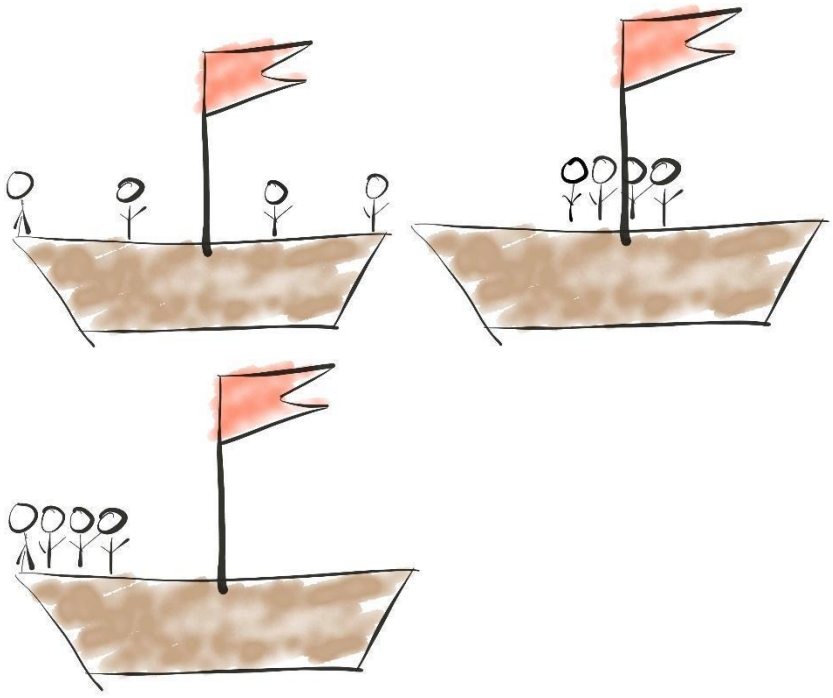
Objectives

- Relate density to weight distribution in the ability of objects to float in water.
- Explore how weight/mass influences maneuverability using canoes.
- Practice efficient propulsion and control of a vessel.
- Design an experiment to test movement strategies
- Create a series of bar graphs to explore relationships among variables.

Recognize, Recall, & Reflect

In the previous activity, you thought about how the density of objects is related to how they were able to float or sink in water. Now, consider how density of objects inside of other objects relates to how well they float (or sink).

Look at the following three images of people in boats. ***Circle the boat that you think will float the best in water.***



Explain your thinking and discuss how weight distribution will affect the way a boat floats in the water?

_____
_____
_____

_____

_____

Give the advantages and disadvantages of each of the following three characteristics of a canoe for transporting materials in Table 1.4.

Table 1.4 ***Advantages and Disadvantages in Using a Canoe for Transporting Materials***

Strategies	Advantages	Disadvantages
Canoe shape?		
Canoe stability?		
Canoe maneuverability?		

Think Before you Do

Describe how you think weight distribution will affect your control of a canoe. Consider how this may affect the design of your cardboard boat.

_____

_____

_____

_____

_____

Observe and Report

You will be given a 2-person canoe, oars, and 5 one-gallon jugs pre-filled with water (please do not open the jugs). Practice differing methods of rowing without jugs. Make sure to practice steering.

Design Activity

Your goal is to determine how to maneuver a canoe quickly and effectively with cargo. Pick the strategies and run your experiment with both no gallons and 5 gallons of water. Load the canoe according to the experiment you design and paddle around the pool. Test how the jugs' weight and placement, along with rowing strategies, affect the stability and movement of the canoe. Time the movement across the water. Record your observations and times in Table 1.5.

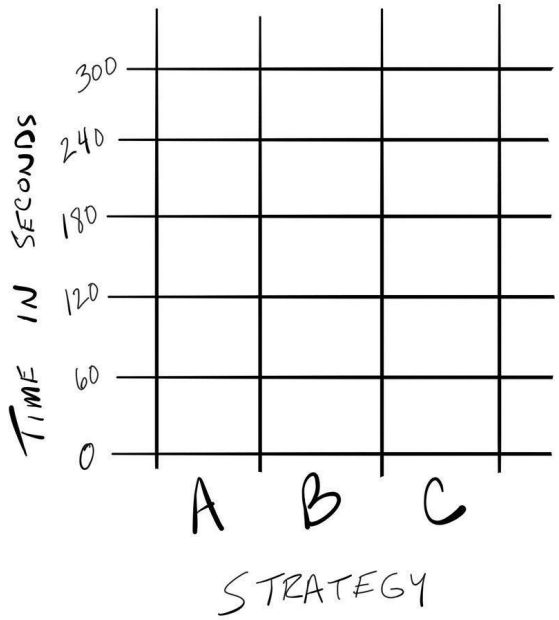
Table 1.5. *Experimenting with Strategies in a Canoe*

Strategies	Observations *No Gallons*	Observations *5 Gallons*

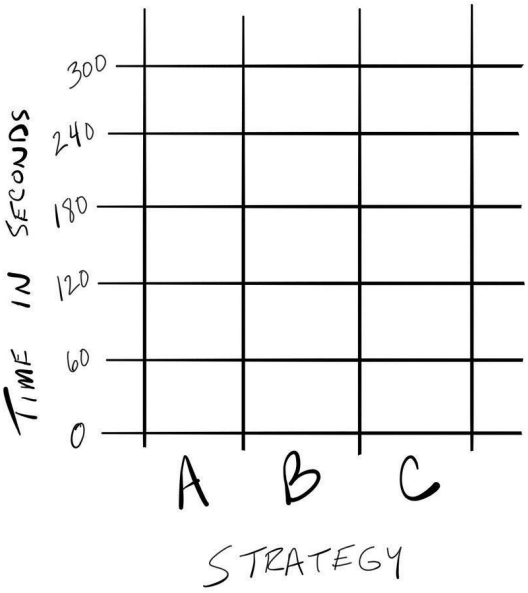
	(include time in seconds)	*(include time in seconds)*
Strategy A:		
Strategy B:		
Strategy C:		

Complete the bar graphs by shading in the column of your data.

Zero Gallons



5 Gallons



Based on your data, what have you learned? Is there a strategy that is fastest without the heavier load? Is that strategy still the fastest when you have the extra weight?

_____

_____

Please complete the following exit ticket.

Rank your activities today, with 1 for the skill you used the **most** and 4 for the skill you used the **least**.

Skill	Collaboration	Creativity	Communication	Critical Thinking
Definition	*working and sharing with others on a common goal*	*brainstorming and making new ideas*	*sharing thoughts with written or spoken words*	*using information to solve problems*
Your Rank:				

1. Give an example of how you used your top skill (the one you ranked 1 above).
   _____
   _____
2. What was the most interesting thing you did today?
   _____
   _____
3. What is a question that you had today that didn't get answered?
   _____
   _____

Appendix C

Day: Two
Activity: Mini Challenge

Student Name: _____
School Name: _____

Objectives:

- Observe how long it takes for different shapes to float/sink in water.
- Discover how the shape of a boat relates to its ability to hold objects and float.
- Calculate how weight and shape influence the speed of boats using ratios.

Recognize, Recall, & Reflect:

Predict how long a 10 cm x 10 cm square of cardboard will float on water before sinking? (Be sure to include a unit label) _____

Watch the time lapse video (https://bit.ly/STEMvid1) of various cardboard shapes suspended in water over time. What did you notice about the cardboard floating/sinking? Describe 2 things.

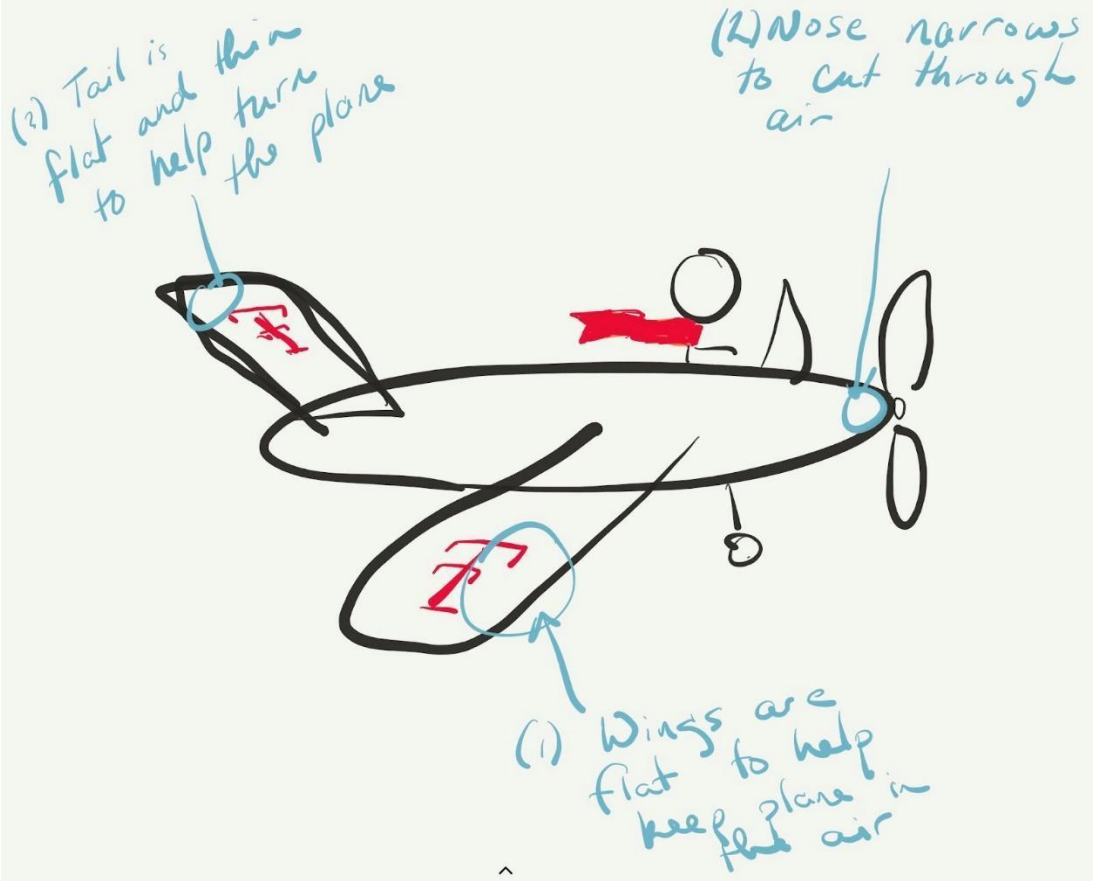
_____
_____
_____

Think Before You Do:

Draw which shape of boat you think would float best. Consider how a boat floats in water.

- Label 3 things in your sketch that make the boat's <u>shape</u> effective for completing the challenge.
- Rank those three things in importance by placing a 1, 2, and 3, next to it.

If you need help, consider the drawing of the airplane on the next page:



<u>Observe & Report:</u>

Your team will be given a wading pool, 20 marbles and 2 sheets of tin foil measuring 30 cm x 30 cm that you can use to design 2 vessels as different boat shapes. As a team, propose two possible tin foil boat designs for efficiently transporting the maximum number of marbles across the pool. Once the group has reached a consensus on the two designs, make a quick sketch at the top of Table 2.1 below.

Once everyone has completed their sketches, work as a team to construct and test each boat design - once without marbles, once with marbles - noting the times. See which of your two boat designs supports the marbles better (weight distribution) and how quickly each design goes through water with a single push (reducing water resistance).

Conducting your test:

1. Record all of the “Predict” entries in Table 2.1
2. Bring your boat prototype to the testing pool.
3. The pool should be marked with two pieces of string spaced 60 cm apart. The first string is the starting line, the second is the finish line. For time trials, the time starts when any part of your boat crosses the first string, and it ends when any part of the boat crosses the second string.
4. Inside the starting area (behind the first string), place your model boat on the water. If your trial calls for marbles, load the marbles.
5. Position the boat behind the starting line and prepare to start your stopwatch.
6. Your teacher will “launch” the boat to push it from the starting area toward the finish line. Note that their hand cannot cross the starting line!
7. Time stops when a part of the boat crosses the finish line.
8. Record the results of each test in Table 2.1

Testing Overview

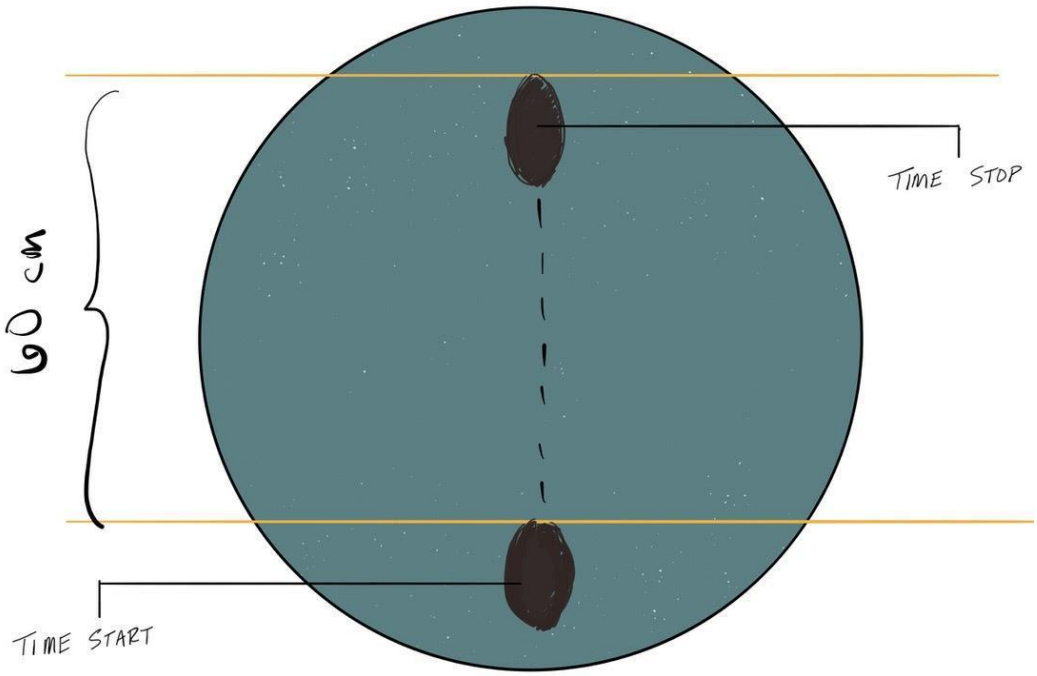


Table 2.1 *Boat movement in the water*

Draw the shape of boat designs. Design 1 / Design 2	**<u>Predict</u> Column A:** How far do you think your boat will go in cm?	**<u>Predict/ Record</u>: Column B:** *Predict*: Will it float with 20 marbles? *Record*: Did it?	**<u>Record:</u> Column C:** How far did the boat go before it stopped?	**<u>Record:</u> Column D:** How many seconds until it stopped?	**<u>Calculate:</u> Column E:** Calculate the <u>speed</u> (distance / time)?
Design 1 (without marbles):					
Design 1 (with marbles):		P: yes / no R: yes / no			
Design 2 (without marbles):					
Design 2 (with marbles):		P: yes / no R: yes / no			

Describe the benefits and drawbacks of each of your boat designs.

Table 2.2 Benefits and Drawbacks in Boat Design

	For Weight Distribution		**For Water Resistance**	
	Benefit	**Drawback**	**Benefit**	**Drawback**
Design 1: (without marbles)				
Design 1: (with marbles)				
Design 2: (without marbles)				
Design 2: (with marbles)				

<u>Formulate & Create:</u>
You will receive a new sheet of 30 cm x 30 cm tinfoil. For today's challenge, your team will design and construct the best possible boat for moving marbles across the test pool. The team

that successfully moves the most marbles across the pool (60 cm, using the same rules as the testing in the Observe and Report section) will win first prize! For tie breakers, the quickest journey will win.

Work with your team to come to consensus on the best possible design for moving as many marbles across the test pool as possible. Sketch your group's final design below.

Table 2.3. *Make your individual assessment by filling in the boxes of this table.*

	Individual Responses
How many marbles do you think your team's boat will be able to safely carry from the starting area to the finish line?	
Justify your prediction	

Table 2.4. *Come to consensus with your team by filling in the boxes of this table.* ***This prediction locks in how many marbles must be loaded into the boat for your challenge attempt. If your boat sinks or fails to reach the finish line, your team will be scored ZERO for this challenge!***

	Final Responses
How many marbles did your team decide the boat will be able to safely carry from the starting area to the finish line?	
Did your boat successfully carry the marbles to the finish line?	
If you could, what would you change to make a more successful attempt?	

Appendix D

Day: Two
Activity: Design Challenge

Student Name: _____
School Name: _____

Objectives

- Assess your interests to determine your role in the building project.
- Affirm your group norms.
- Design boat within the budget constraints.
- Outline budget using different prices for objects.
- Reconcile your initial boat design to your proposed budget.

Recognize, Recall, & Reflect:

What part of the building process interests you the most?

Interest refers to something that I would choose to spend my time doing or something that I would want to learn. Interest can include being curious about or fascinated by something.

Check the following statements under each column that interest you.
Your teacher will review your responses and notify you of your official role in the building project.

Table 2.5 Project Role Interest Inventory

CONSTRUCTION ENGINEER	CARGO SPECIALIST	MATERIALS ENGINEER	COMMUNICATIONS SPECIALIST
❑ Learning how tools work ❑ Taking things apart ❑ Putting things back together ❑ It's more important to know how to build something than how it works	❑ Figuring out the weight of something ❑ Keeping things from breaking ❑ Breaking things on purpose ❑ It's more important to know how to keep something from breaking than fixing it	❑ Figuring out how to organize things ❑ Understanding the differences between uses of materials ❑ Estimating how much material a project needs ❑ It's more important to have everything in place before you start a project than start without them	❑ Practicing and representing my team ideas to the public ❑ Helping others understand what is going on ❑ Explaining something complicated to others ❑ It's more important to talk through an idea with others than try to figure it all out by yourself
COUNT: _____	COUNT: _____	COUNT: _____	COUNT: _____
Let's affirm our group norms as the ways we best communicate and agree with others: ❑ We will speak calmly, clearly, concisely. ❑ We will reach consensus on design plans and changes. ❑ We will give and receive help, regardless of the role.			

Think Before You Do:

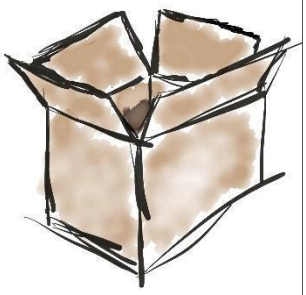
Review earlier boat designs from Day 1 and 2 mini challenges. As a group, share your ideas and develop a boat design using elements you all think will ensure victory on Day 5! ***Draw your group's boat design.***

Individually, point out 3 things in your picture that make your group boat design effective for completing the challenge. ***Rank those three things in importance by placing a 1, 2, and 3, next to it.*** *Note that the three things you think are most important may not be the same as others in your group.*

Observe and Report

For your boat, you will receive a base kit*, which consists of five large-sized boxes, five medium-sized boxes, and two rolls of duct tape. However,* ***this base kit does not contain enough materials to complete your boat.*** *Using your new roles and design, determine any additional amounts you will need for your boat.*

Table 2.6 *Additional Construction Materials for your Boat Design*

			
five large-sized and five medium-sized <u>boxes</u>	*two rolls of <u>duct tape</u> (~46 meters ea.)*	*None in base kit*	*None in base kit*
Individual Thinking:			
How many additional boxes? _____	How many additional rolls of tape? _____	Do you need this? Y/N? If Yes, how many? ____	Do you need this? Y/N? If Yes, how many? ____
Group Consensus:			
How many additional boxes? _____	How many additional rolls of tape? _____	Do we need this? Y/N? If Yes, how many? ____	Do we need this? Y/N? If Yes, how many? ____

<u>Design Activity:</u>
You are being given <u>6,000 units</u> **to purchase items for your boat.** Examine the purchase order below. Also, if you won any additional units from the previous day's Mini-Challenge, add those units to your budget now. Consider if you can afford everything your group identified in the "Think Before you Do" section.

Now, your team must decide on a preliminary budget, keeping in mind, you may want to keep part of your budget to purchase additional materials after you build your boat the next day. After your team has completed your Purchase Order (below) send your Materials Engineer to the STEM Challenge store. Have the Communications Specialist note how much was spent for future purchases.

School Name:

STEM Challenge Day 2 PO

DATE	6/7/2021
P.O. #	1

VENDOR	SHIP TO (Teacher Name)
STEM Challenge Marketplace	

ITEM #	DESCRIPTION	QTY	PRICE	TOTAL
111111	Tape		3,000.00	
222222	Cardboard Box		1,500.00	
333333	Poster Tube		1,500.00	
444444	Bubble Wrap		2,500.00	
			TOTAL	

Other Comments or Special Instructions
Note: You have a budget of 6,000.00 units
Additional Funding:

Materials Engineer Signature Date

Please complete the following exit ticket.

Rank your activities today, with 1 for the skill you used the **most** and 4 for the skill you used the **least**.

Skill	Collaboration	Creativity	Communication	Critical Thinking
Definition	*working and sharing with others on a common goal*	*brainstorming and making new ideas*	*sharing thoughts with written or spoken words*	*using information to solve problems*
Your Rank:				

1. Give an example of how you used your top skill (the one you ranked 1 above).
   _____
   _____
2. What was the most interesting thing you did today?
   _____
   _____
3. What is a question that you had today that didn't get answered?
   _____
   _____

Appendix E

Day: Three
Activity: Mini Challenge

Student Name: _____
School Name: _____

Objectives:

- Discuss the concepts of crush and tilt and how these can damage a ship's cargo.
- Design and construct a cargo container for a safe delivery of cargo.
- Develop a prototype for a cargo container.
- Measure the efficacy of your prototype using crush and tilt factors.

Recognize, Recall, & Reflect:

What do you think is important when Amazon is delivering packages?
What things are important when you have your packages delivered to where you live?

_____

_____

Think before you do:

Tilt and Crush are important aspects when transporting fragile and/or dangerous cargo. Imagine you are shipping a glass container of flammable liquid. You don't want the container to tip over (tilt) while you are moving it and pour out the contents in transit. You also don't want the container to break (crush) if someone stacks a box on top of it.

Your shipping company will be asked to transport two types of cargo. Today you will prepare to transport 2 raw eggs in a sealable plastic cargo container. The egg container cannot be opened, and you must construct a package around the container. Consider how you will address issues of crush and tilt when transporting this delicate cargo across the pool.

Develop your ideas by sketching out TWO designs below to protect the 2 eggs (cargo) in the container.

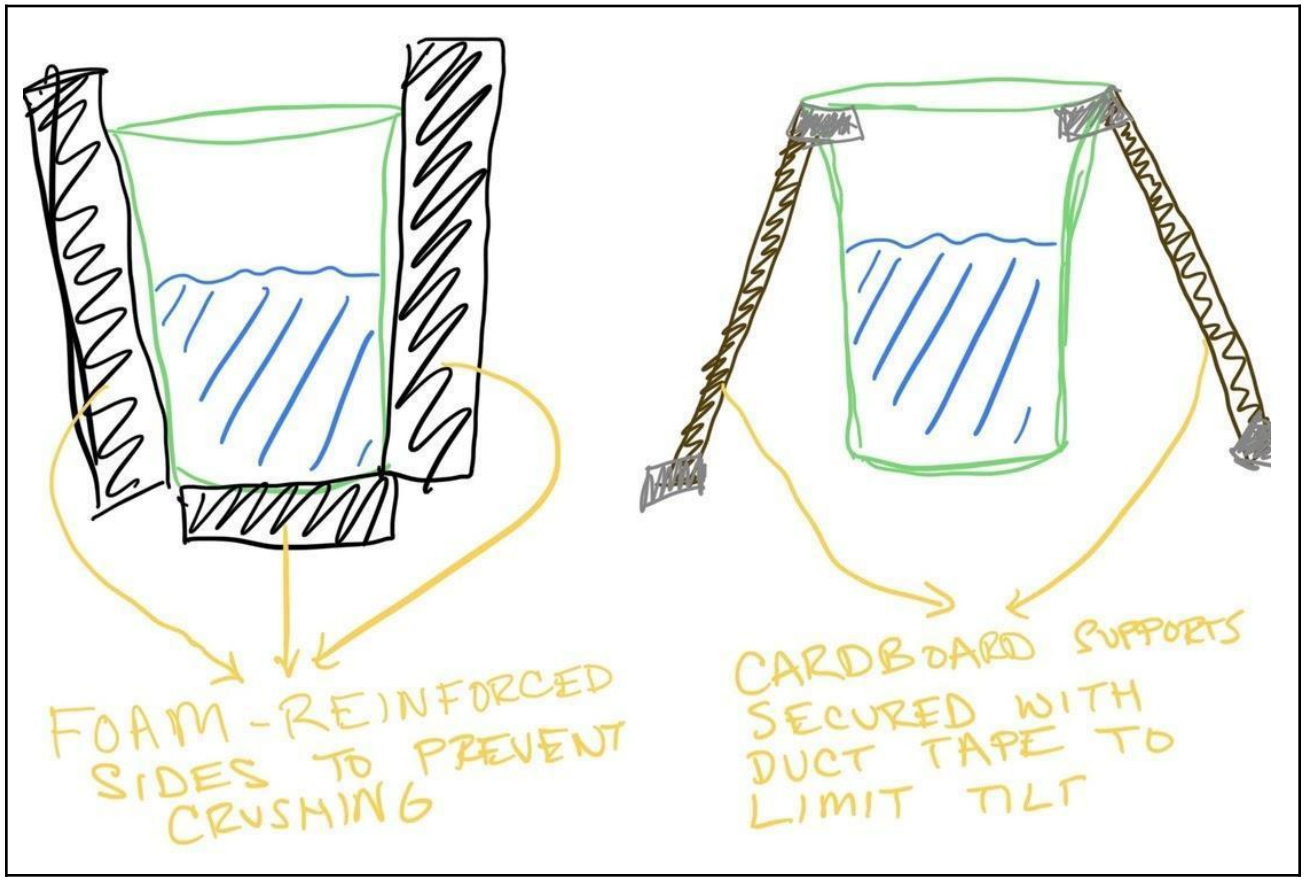
Table 3.1 *Ideas to reduce tilt and crush concerns of the cargo within your boat design.*

TILT	***CRUSH***

Point out 1 thing in each picture that makes your cargo container minimize tilt and crush.

If you need help, consider the drawings of reducing crush and tilt on a glass of water:

CRUSH	***TILT***



Observe & Report:
In your group, share your two ideas to reduce tilt and crush. Develop a group prototype that merges your group's ideas on tilt and crush. Draw your group's design in the box.

Label how your group decided to reduce tilt and crush in your group's cargo prototype.

Using the following materials, construct your prototype support system.

Cargo Materials	Measurement Tools	Build Tools
• Loose packing material • Foam • Bubble wrap • PVC pipe • Cardboard (40cm x 40cm) • Plastic shipping container	• Hand lens • Tilt Sensor • Timer • Meter Stick	• Scissors • Ruler

Formulate & Create:

Test your prototype to see how well your design meets the tilt and crush challenge. You will test your prototypes in two sessions, first for tilt and then for crush.

1. **Tilt**: Your cargo container prototype (containing the sealed egg container) will be placed on a shake table for 20 seconds.
2. **Crush**: Your cargo container prototype (containing the sealed egg container) will be dropped from a height of 1 meter.

You will be judged on two categories. The group with the least damage wins free bubble wrap!

1. Record the level of Crush and tilt damage.

a. Tilt damage is measured by the **number and length of cracks in the eggs.**

i. Heavy Damage = Significant shell damage, white and yolk visible (0 points)
ii. Moderate Damage = Large enough hole in shell to see either white or yolk (1 point)
iii. Light Damage = Cracks in shell visible but no white or yolk visible (2 points)
iv. No damage = No visible cracks in shell (3 points)

b. Crush damage is based upon the **number and length of cracks in the eggs.**

i. Heavy Damage = Significant shell damage, white and yolk visible (0 points)
ii. Moderate Damage = Large enough hole in shell to see either white or yolk (1 point)
iii. Light Damage = Cracks in shell visible but no white or yolk visible (2 points)
iv. No damage = No visible cracks in shell (3 points)

2. Fill in the Results below from your Prototype testing in Table 3.2. Share with your teacher to see how your group fared against other groups. The winning group receives an advantage.

Table 3.2. *Prototype Testing Results*

Test Results	**Measured Tilt Damage** (Heavy, Moderate, Light, or None)	**Measured Crush Damage** (Heavy, Moderate, Light, or None)

My Team Prototype		
Points Earned		
	Total Score:	

1. Record the benefits and drawbacks for each design in Table 3.3.

Table 3.3. *Benefits and Drawbacks in Prototype Cargo Container*

Assessment of Prototype	**For Tilt**		**For Crush**	
	Benefit	**Drawback**	**Benefit**	**Drawback**
Group Prototype				

Appendix F

Day: Three
Activity: Design Challenge

Student Name: _____
School Name: _____

Objectives

- Reflect on the important scientific elements of the preliminary boat design.
- Consider new structural elements (e.g., cardboard and tape) for your cargo container design.
- Explore different prices for objects (constraint of budget) for your cargo container design.
- Build and create your own tilt sensor.
- Begin your boat builds, cargo container builds and tilt sensors using your group boat design.

Recognize, Recall, & Reflect:
On your own, identify the strengths and challenges of your group's boat design and cargo container.

- Place a checkmark in two boxes that you think are the greatest strengths of the design.
- Place an X in two boxes that you think are the greatest challenges or concerns.

❑ Maneuverability	❑ Shape	❑ Buoyancy	❑ Propulsion	❑ Speed
❑ Surface Area / Weight Distribution	❑ Durability	❑ Stability	❑ Team Coordination	❑ Damage

Think Before You Do:
After you have finished, share your self-assessments from the previous section with your group.

- What were the common areas of **strength** in your design?
- What were the common areas of **concern** in your design?

Discuss how your group's observations inform changes to the boat design, cargo container and construction plan. Record at least two changes from your group's discussion on strength and/or concerns:

Change 1 _____

Change 2 _____

Observe & Report:
To protect your cargo and complete your boat, *explore the* ***three new marketplace items*** *for cargo protection. Using your roles assigned on day 2 and designs, determine the amount you need of each additional material, if any. As a reminder, eggs will be inside the provided plastic container.*

Table 2.6 *Additional Construction Materials for your Boat Design*

		
Sheet of Foam	*Loose Packing Materials*	*PVC Pipe*
Individual Thinking:		
Do you need this? Y/N? If Yes, how many? ____	Do you need this? Y/N? If Yes, how many? ____	Do you need this? Y/N? If Yes, how many? ____
Group Consensus:		
How many additional packs? _____ (enter 0 if no)	How many peanuts? _____ (enter 0 if no)	How many lengths of PVC? _____ (enter 0 if no)

Please examine the purchase order below.

- **You are given 2,000 units to purchase additional items for your cargo container and boat (if needed).**
- Make sure to verify that you can afford everything your group identified in the “Observe & Report” section.
- If you need to order more boat supplies, include them on the same purchase order.

This is the last order for purchase of additional materials. Once you have reached consensus, submit your final purchase order on the next page.

[School Name]

STEM Challenge Day 3 PO

[Team Motto]

DATE	5/13/2021
P.O. #	1

VENDOR	SHIP TO
[Emcee Name]	Attn: [Teacher Name]
STEM Challenge Marketplace	[School Name]

ITEM #	DESCRIPTION	QTY	UNIT PRICE	TOTAL
111111	Tape		3,000.00	
222222	Cardboard Box		1,500.00	
333333	Poster Tube		1,500.00	
444444	Bubble Wrap		2,500.00	
555555	Sheet of Foam		3,000.00	
666666	Loose Packing Material		500.00	
777777	PVC Pipe		1,000.00	
			TOTAL	

Other Comments or Special Instructions

Note: You are now being given an additional budget of $2,000.00

CFO Signature Date

Design Activity:

Your client has one final request! Your company will not only need to transport the delicate cargo of two raw eggs from the launch point to the mid-way dock. Now, they need you to retrieve a second cargo and safely transport it back to the launch site. This new cargo is an unstable chemical that could be damaged if tipped more than 30 degrees and completely ruined if tipped more than 60 degrees. (Don't worry, it's actually two gallons of drinking water!) You have been provided a small emergency kit of materials (cardboard, marble, clear plastic wrap, and tape) to design and fabricate a sensor that will allow you to detect if your cargo has been critically tipped 30*, 60*, or 90* as evidence to your client of a safe delivery.

Here is an example of a commercial sensor that you may use as a pattern:
https://spotsee.io/tilt/tiltwatch-plus

Your tilt sensor(s) must pass a quality control that will successfully measure a 30-, 60- and 90-degree tip *in both directions*. If your sensor fails, you can alter it and request additional quality-control checks. If your team is unable to create a functional sensor, sailing without a sensor will assume the scoring penalty for a full 90-degree tilt during the challenge.

Please use the remainder of your time in this session to begin constructing your boat and cargo container in alignment with the group's design.

Please complete the following exit ticket.

Rank your activities today, with 1 for the skill you used the **most** and 4 for the skill you used the **least**.

Skill	Collaboration	Creativity	Communication	Critical Thinking
Definition	*working and sharing with others on a common goal*	*brainstorming and making new ideas*	*sharing thoughts with written or spoken words*	*using information to solve problems*
Your Rank:				

1. Give an example of how you used your top skill (the one you ranked 1 above).
   _____
   _____

2. What was the most interesting thing you did today?
   _____
   _____

3. What is a question that you had today that didn't get answered?
   _____
   _____

Appendix G

Day: Four
Activity: Mini Challenge

Student Name: _____
School Name: _____

Objectives:

- Observe different strategies to move cargo across the United States.
- Explore strategies, within your design, that best ferry cargo across the pool.
- Develop a presentation to defend your strategies to be successful in the STEM Challenge.

Recognize, Recall, & Reflect:
How do different vehicles (i.e., airplane, barge, truck) handle and deliver cargo differently?

- Airplane: _____
- Barge: _____
- Truck: _____

Think before you do:
Recall that the Cargo you will transport in the STEM challenge are 2 raw eggs within a sealable plastic cargo container. Once you deliver the cargo, you are now asked by the shipping company to return with an additional cargo of raw material (2 gallons of water). *See the example drawn on the right.*

Instead of crush or tilt with your original cargo, the two concerns generated by the new cargo are balance (to the front (bow) and back of back the boat (aft)) and counterbalance (to the right (starboard) and left (port)).

Identify two additional challenges or constraints you will need to address in your design and build to accommodate this heavier cargo. Once identified, sketch your ideas in Table 4.1

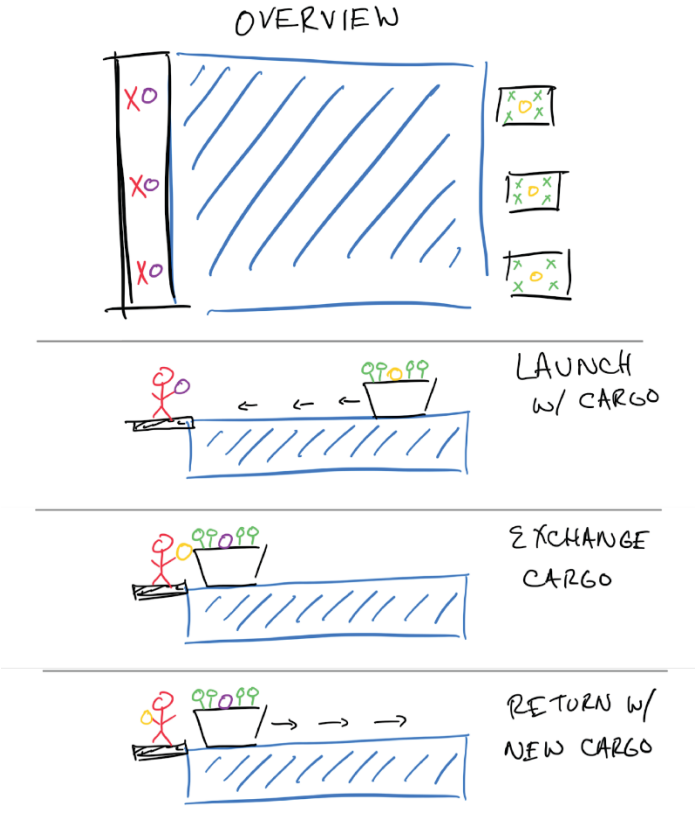


Table 4.1 *Balance and Counterbalance Considerations when Taking on New Cargo (Water Jugs)*

BALANCE taking on NEW CARGO	***COUNTERBALANCE taking on NEW CARGO***

Point out 1 thing in each picture that directly addresses balance and counterbalance issues.

Observe & Report:
In your group, you will share your two ideas to maintain balance and counterbalance. Share your ideas to enhance your group design and build that merges your ideas with the group.

Draw your understanding of the group's enhanced design or plan in the box.

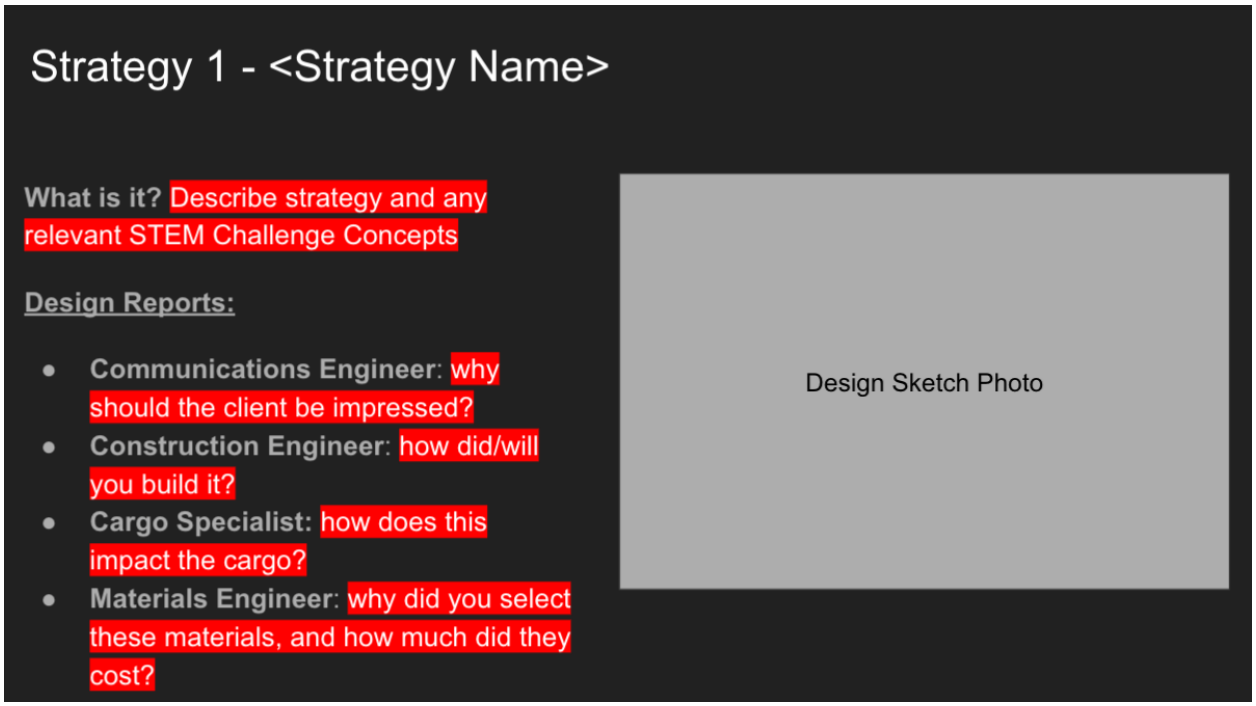
Label how your group decided to address balance and counterbalance in your group boat design.

Formulate & Create:
You will give an update to the client describing your strategies for most effectively transporting the cargo to the destination and the new cargo back to the starting point. Your client update should describe **3 specific strategies** that your company is using to give your team an advantage.

Also, make sure to use **at least 3 of these STEM Challenge Concepts** from your previous work to highlight how you have integrated lessons learned into improving your design:

1. ***Maneuverability*** *(steering and turning the boat)*
2. ***Surface Area / Weight Distribution*** *(weights in the boat over the bottom of the boat)*
3. ***Shape*** *(maintaining the shape or structure of the boat, not deforming in water)*
4. ***Durability*** *(keeping the Watertight and not sinking)*
5. ***Buoyancy*** *(keeping the boat above the water line, not taking in water)*
6. ***Stability*** *(not tipping over the boat)*
7. ***Propulsion*** *(rowing the boat)*
8. ***Team Coordination*** *(How team members act in the boat to accomplish the STEM Challenge)*
9. ***Speed*** *(Getting across the pool, delivering and receiving cargo, and going back in the fastest time)*
10. ***Damage*** *(ensuring the boat and/or cargo isn't harmed: crush/tilt, balance/counterbalance)*

Record your presentation on the slides provided to you or write your responses to the red parts on each of the three slides. Here is the slide for Strategy #1.



A rubric will be used to determine the best pitch, and therefore, the winner of this challenge. The presentation should reflect your roles determined on Day 2 to accurately describe cargo challenges and the plan to address them.

Winners receive a bonus to their profit of 2500 units for first place, 1500 units for second place, and 500 units for third place.

Appendix H

Day: Four
Activity: Design Challenge

Student Name: _____
School Name: _____

Objectives

- Assess your group's progress towards the goals of the STEM Challenge.
- Explore different prices for objects (constraint of budget) for the cargo container.
- Consider what monies are remaining in the budget that can increase your profit (Math Connection).
- Continue building your boat and cargo container from the group designs.

Recognize, Recall and Reflect:

It is important to build with the end in mind. Let's check in with the tasks you have to do for the STEM Challenge and:

- Place a checkmark in the box that you think are the greatest strengths of your build.
- Place an X in the box that you think is the greatest challenge or concern of your build.

❑ Not sinking, tipping, or taking in water.	❑ Being able to turn the boat around from the cargo line.	❑ Having a Cargo Container that won't damage the cargo.
❑ Being the fastest to the cargo line.	❑ Being the fastest from the cargo line.	❑ Transferring different types of cargo between the boat and dock.

Think Before You Do:

After you have finished, share your self-assessments from the previous section with your group.

- Consider, what were the common areas of **strength** in your build?
- Consider, what were the common areas of **concern** in your build?

Observe & Report:

Gather your sketches to use for your boat and cargo builds. Verify your budget to see the amount of money your group has left going into the STEM Challenge. Remaining money will serve as part of your profit.

Design Activity:

Finish building your boat and build your cargo container. Make sure to adhere to group norms and roles to ensure a build that honors everyone's input for both the boat and cargo design.

Before leaving for the day, please complete the exit ticket on the following page.

Please complete the following exit ticket.

Rank your activities today, with 1 for the skill you used the **most** and 4 for the skill you used the **least**.

Skill	Collaboration	Creativity	Communication	Critical Thinking
Definition	*working and sharing with others on a common goal*	*brainstorming and making new ideas*	*sharing thoughts with written or spoken words*	*using information to solve problems*
Your Rank:				

1. Give an example of how you used your top skill (the one you ranked 1 above).
   _____
   _____

2. What was the most interesting thing you did today?
   _____
   _____

3. What is a question that you had today that didn't get answered?
   _____
   _____

Appendix I

Day: Five
Activity: Mini Challenge

Student Name: _____
School Name: _____

Objectives:

- Reflect on how your job in the group contributed to the final boat and cargo build.
- Consult with your teammates on other contributions you made to the final boat and cargo build.
- Consider how other groups creatively made their final builds.
- Communicate with community members and convince them that your team's build is the best.

Recognize, Recall, & Reflect:
You have come so far! You started with cardboard, duct tape, and some great ideas. Now, it's almost time to actually launch your boat and precious cargo to reach the destination! Take a moment to remember all the work you've done this week. You worked with your team to design, construct, test, and improve your boat. Even though you only see your boat and cargo (product), it is important to appreciate and honor the teamwork and creativity that made the boat.
Write down your job title (Construction Engineer, Cargo Specialist, Materials Engineer, or Communications Engineer) and give two examples of how you contributed to your team's project. For example, if you're thinking about "teamwork," don't just write the word. Describe a specific example of how you worked for the team to solve a problem.

Title: _____

Contribution 1: _____

Contribution 2: _____

Think Before You Do:
Turn to one of your teammates and discuss your contributions. From your conversation, work with your teammate to identify a third contribution you made to the project.

Contribution 3: _____

Observe & Report:
Take some time to walk around and look at the other boats. In the box below, sketch and label two interesting design elements you found from other teams' cargo containers or boat builds.

Next, take a few minutes to vote for the other shipping companies in the categories listed below. **Keep in mind, you CANNOT add your own school to this list.**

Table 5.1 *Superlatives Rubric for Participants and Guests*

Write in for the team you believe is the best in each category (you may leave some categories blank).			
Most Professional		Most Safe	
Best Boat Design		Best Teamwork	
Best Cargo Design		Write in category: _____	
Most Creative			
Note: You may use this ballot to collect information from the crowd to determine superlative winners, which can be announced after the STEM Challenge has completed.			

Formulate & Create:

Now, work with your team to *sell* your shipping company as the best option for moving cargo on the high seas! As friends, teachers, family, and community members tour the competing shipping companies, make sure they understand why your team is the one to pick!

To be successful in your discussion with the clients, make sure:

- Each team member can talk to a specific **contribution** they made
- To talk about the **boat** design and how the design guided the build
- To talk about the **cargo** design and how the design guided the build
- To describe how your team will work together for **safety**
  (rowing efficiently without tipping)
- To describe how your team will work together for **efficiency**
  (being positive and supportive of your team and its work)

The winning group of this mini-challenge receives a time bonus!

- 5 seconds for first place
- 3 seconds for second place
- 1 second for third place

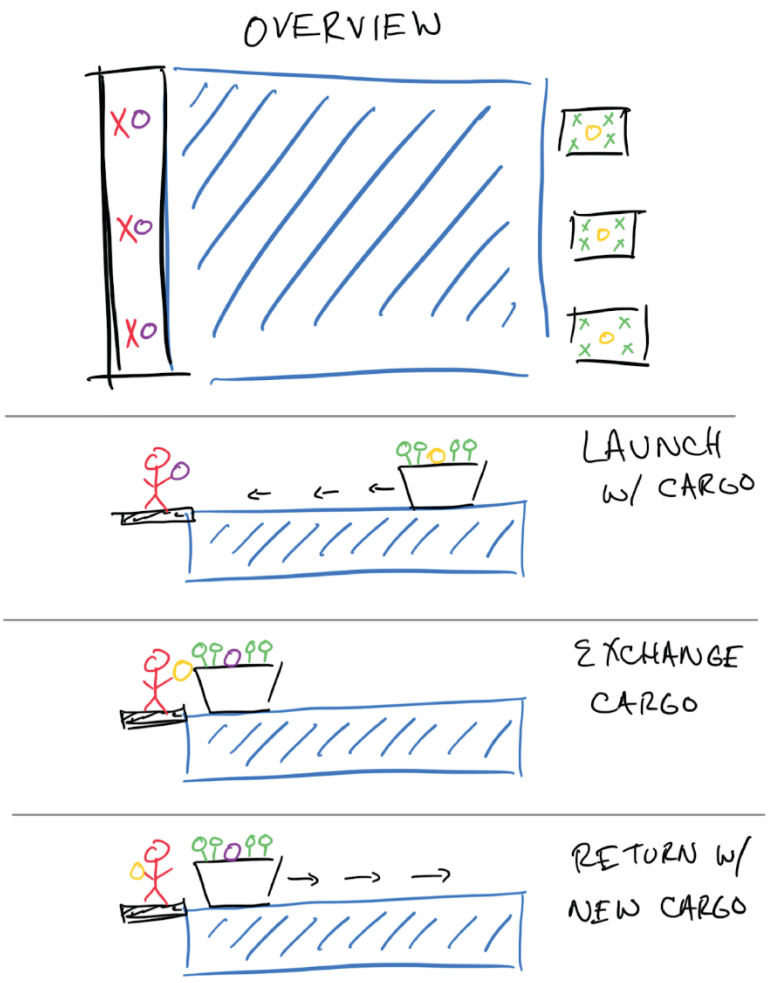
Appendix J

Day: Five
Activity: Design Challenge

Student Name: _____
School Name: _____

Objectives

- Review the rules for a fair STEM Challenge Contest.
- Race your builds across the water by exchanging your cargo and rowing back to the original port.
- Calculate the "winner" of the STEM Challenge Event.



<u>Time for STEM Challenge:</u>
The time has come! It is time to test your builds in the water. Before you begin, there are a few rules to ensure that everyone participating is aware of the rules and that the process is fair to all groups.

Rules:

- The contest can be run in heats depending on the size of your pool (or other body of water).
- Before a heat begins, boats must be entirely out of the water.
- Each team member must have both feet on the ground and at least one hand on the boat.
- Only one team member can be holding the egg cargo container.
- Launch your boat when the signal sounds.
- Time starts when the signal sounds and stops when the second cargo is successfully unloaded.
- Tipping or crushing your cargo results in a penalty.
- The winning team will be determined using the contract payment calculator.

- Remember, being a good sport is essential! Teams that intentionally disrupt another boat or cargo will be penalized.
- The team that generates the largest profit wins!

To determine the winner, we have to determine which team has the most profit or highest payout. To that, we have to consider your score and bonuses. **Should your group be unable to deliver the payload (if your boat sinks, your cargo falls into the water) you will not have completed the contract, and therefore cannot be paid.**

You will be **scored** on the following four factors:
1. Total Time
2. Initial cargo delivery/ Eggs
3. Return cargo delivery/Return weight
4. Being a Good Sport

You will have **additions to your Score:**
1. Day 4 and Day 5 Mini-Challenge Bonuses (1st, 2nd, 3rd place receive bonuses)
1. Remaining money on budget

Please complete the following exit ticket.

Rank your activities today, with 1 for the skill you used the **most** and 4 for the skill you used the **least**.

Skill	**Collaboration**	**Creativity**	**Communication**	**Critical Thinking**
Definition	*working and sharing with others on a common goal*	*brainstorming and making new ideas*	*sharing thoughts with written or spoken words*	*using information to solve problems*
Your Rank:				

1. What was your favorite thing about today's race or the entire STEM challenge?

   _____
   _____

1. What did your team (or another team) do well that you had initially thought would not work?

   _____
   _____

1. What was one thing you or your team figured out that gave you an advantage over other groups?

   _____

   _____

1. If you had to start the Challenge all over again, what would you change?

   _____
   _____

Appendix K

This is the teacher's guide for the 5-day STEM Challenge Curriculum. In this document, you will find information to support students through the event, in both morning (mini challenge) and afternoon (design challenge) events. This includes student objectives, curriculum alignments to the Next Generation Science Standards (NGSS), the International Society for Technology in Education (ISTE) national technology standards for students, and the Common Core State Standards (CCSS). Teacher's activities, preparation, and assessments (answer keys) are included.

Teacher Guide Use: Each day is outlined: overview, objectives, teacher/mentor actions, preparation, target vocabulary, assessment and answer keys. The details for the mini challenges and design challenges are combined in the teacher guide for ease of preparation, but written in chronological order in student documents.

Pre-Challenge Prep:

Before beginning the STEM Challenge, acquire the following supplies and space for the week:

- Each team will need a working space of *at least* 50-100 square feet. Keep in mind the constraints of boat size if students have to move boats through doors and hallways to access the pool, they will be racing in. **Building works best when it is not actually near the pool. Oftentimes, it is in a separate location. Be prepared to have a trailer, truck, U-Haul, etc. to help move boats between locations.
- Boat Building Supplies: clipboards, writing utensils, rulers/tape measures, protractors, box cutters, cardboard, duct tape, other building materials as available in the STEM Challenge Store.
- Mini-Challenges and Design Challenges each have a specific set of needed materials as well. It is helpful to gather and assemble kits the week before.
- Personal flotation devices for each student who will be in the water on race day. In addition, lifeguards on duty at the pool increase safety, and are helpful to help pull water-saturated cardboard out of the pool, as it gets heavy.
- In addition to scheduling the pool for race day, Day 1 Design Challenge requires access to instructors, canoes and gear for students.
- Access to four oars per team (or rotating per heat) for all members of teams racing.
- One teacher and older student mentor (college student or high school student) per team of four middle school students. Encouraging two males and two females per team is helpful for balance, effectiveness and inclusion.
- Communicate expectations for lunches and liability, if applicable. Clearly communicate to students when they should wear swimsuits and bring towels.
- Print provided mini-challenge and design challenge student documents for all students and teachers.
- Several days include opportunities for unbiased judges for grading activities. These can be teachers, VIPs, administrators, or others. Most notably, these people have been used as judges during the mini challenges on Day 4 and Day 5, since the rewards have an impact on the overall STEM Challenge winners.
- Invitations and publicity can be pushed out to the public, administrators, parents and other students to attend the final STEM Challenge on race day.

Day 1 Overview:

On the first day of the STEM Challenge, students learn about the notion of shipping and how different objects float in water via density (mass and volume). They will use their observation and estimation skills to explore the materials (e.g., cardboard, duct tape) that will be used in their boat builds. Students build upon these experiences of density exploring the concepts of weight distribution and buoyancy by exploring variables (e.g., weight, people, oars) that will need to be considered in the future boat design and builds for the week.

STEM Challenge Welcome: Begin the first day of the week with a whole-group introductory session where the Challenge Leader can introduce teams to the competition format, the mini challenge and design challenge structures, and challenge rubric. We recommend addressing the following points.

- Roll Call - make each team choose a name and create a silly team cheer!
- Introduce STEM Challenge support personnel
- Contextual Questions for Students
    - How do products move from one continent to another?
        - Planes, trains, trucks, etc.
    - What kinds of challenges come from moving large amounts of freight across an ocean?
        - hurricanes, large waves, time, loading/unloading cargo, damaged products, etc.
    - Who do we trust to manage these logistics for us?
        - Amazon, UPS, FedEx, DHL, etc.
    - What are some things that might make a shipping company most competitive/successful?
        - Price, speed, reliability, safety, size of boats, etc.
- STEM Challenge Introduction
    - Each team is competing to be the most profitable, reliable, expedient shipping company.
    - Each shipping company will be responsible for designing, constructing, marketing, and then piloting a ship on behalf of the STEM Challenge's fictitious client.
    - While teams will learn more details as they navigate the various challenge elements, here are some basic points that each team needs to understand:
        - Each day will be broken into two segments: a mini challenge (morning) and a design challenge (afternoon). Mini challenges are intended to introduce students to key concepts that students should consider as they navigate the challenge, and there are opportunities to win advantages that could pay off at the end of the week. Design challenges guide the teams through the necessary planning and construction steps needed for the final competition.
        - Boats must be constructed using only supplies from the Challenge-supplied base build kit or obtained through the STEM Challenge store--primarily cardboard and duct tape.
        - Each team must operate within the prescribed budget.
        - Boats must be large enough to hold a four-person team.
        - There will be more details later, but teams will be judged on factors such as cost-effectiveness and speed.

Objectives:
By the end of the day, students will be able to:

Mini Challenge	Design Challenge
• Observe the real-world example of shipping. • Discover how shipping companies win contracts. • Explore how things float in water. • Estimate density of objects. (Math Connection.)	• Relate density to weight distribution in the ability of objects to float in water. • Explore how weight/mass influences maneuverability using canoes. • Practice efficient propulsion and control of a vessel. • Design an experiment to test movement strategies • Create a series of bar graphs to explore relationships among variables.

Curriculum Connections and Alignment:

- *NGSS*: MS-PS1-2.
    - DCI: PS1.A (Structure and Properties of Matter)
    - CCC: Analyzing and Interpreting Data; Energy and Matter; Patterns
    - SEP: Science Models, Laws, Mechanisms, and theories Explain Natural Phenomena
- *ISTE:*
    - Innovative Designer: 4a. Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
    - Creative Communicator. 6c. Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.
- *CCSS:*
    - ELA Literacy: RST.6-8.7 (Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table); RST.6.8-9 (Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
    - Mathematics: MP.2.7.EE.3 (Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies).

Teacher/Mentor Actions:
As the Teacher and/or Student Mentor, you will help support student-directed learning by:

Mini Challenge	Design Challenge
• Support whole-group engagement • Help with drawing and estimation • Facilitate students moving from individual to group assessments. • Evaluate the mini challenge winner(s)	• Observe students as they develop/select strategies • Actively support pool safety and canoe experiment • Reinforce proper rowing technique • Evaluation and Assessment (Exit Ticket)

Preparation:

<table>
<tr><th colspan="4">Mini Challenge</th></tr>
<tr><th>Activity Section</th><th>Materials Needed (per Group)</th><th>Time Suggested</th><th>Additional Considerations</th></tr>
<tr><td>Recognize, Recall, & Reflect</td><td>Printed Documents, Pencils</td><td>20 minutes for overview, 5 minutes to write</td><td rowspan="2">Clipboards may be helpful to students.</td></tr>
<tr><td>Think Before you Do</td><td>Pencils,
Colored Pencils (optional)</td><td>7-10 minutes</td></tr>
<tr><td>Observe & Report</td><td rowspan="2">Standard hard plastic wading pool halfway filled with water, handtowels, 10 x 10 cm squares of cardboard, 10 x 10 cm tinfoil in a ball, standard popsicle sticks, 50cm of duct tape, penny (or other meta coins), 5 cm of PVC pipe of 1 inch diameter, 500 mL sealed water bottle</td><td>5-10 minutes</td><td rowspan="2">If sharing materials, accommodate for that time.

Make sure students are slowing down to make good estimations.

Note if you use PVC of larger diameters it will float instead of sink.</td></tr>
<tr><td>Formulate & Create</td><td>10 minutes for individual rankings

20 minutes for team ranking</td></tr>
<tr><td colspan="4"><u>Optional Extension</u>: If you wish to extend the learning at the end of the mini-challenge, students can calculate the density of objects, given they are able to obtain the mass and volume of the objects. These figures could be given to the students so they can calculate using the D=M/V equation.</td></tr>
</table>

<table>
<tr><th colspan="4">Design Challenge</th></tr>
<tr><th>Activity Section</th><th>Materials Needed (per Group)</th><th>Time Suggested</th><th>Additional Considerations</th></tr>
<tr><td>Recognize, Recall, & Reflect</td><td rowspan="2">Printed Documents, Pencils</td><td>5 minutes</td><td>Students work independently.</td></tr>
<tr><td>Think Before you Do</td><td>5 minutes</td><td>Students work as a group to consolidate their ideas.</td></tr>
<tr><td>Observe & Report</td><td rowspan="2">5 one-gallon sealed water jugs;
4 oars; 1 canoe</td><td>20 minutes</td><td rowspan="2">You will need access to a pool to do this activity. It may be necessary to coordinate special permission for this activity.

If students need to share canoes or pool space, make sure to plan for enough time for each team to complete the full activity.</td></tr>
<tr><td>Design Activity</td><td>60-90 minutes pool time per team</td></tr>
</table>

			Students should have safety training and practice rowing BEFORE beginning their experiment. (You may wish to have a live instructor or show a video similar to this and this.)
Exit Ticket	Pencil	5 minutes	Collect or review exit tickets to plan the next day's activities.

Target Vocabulary:

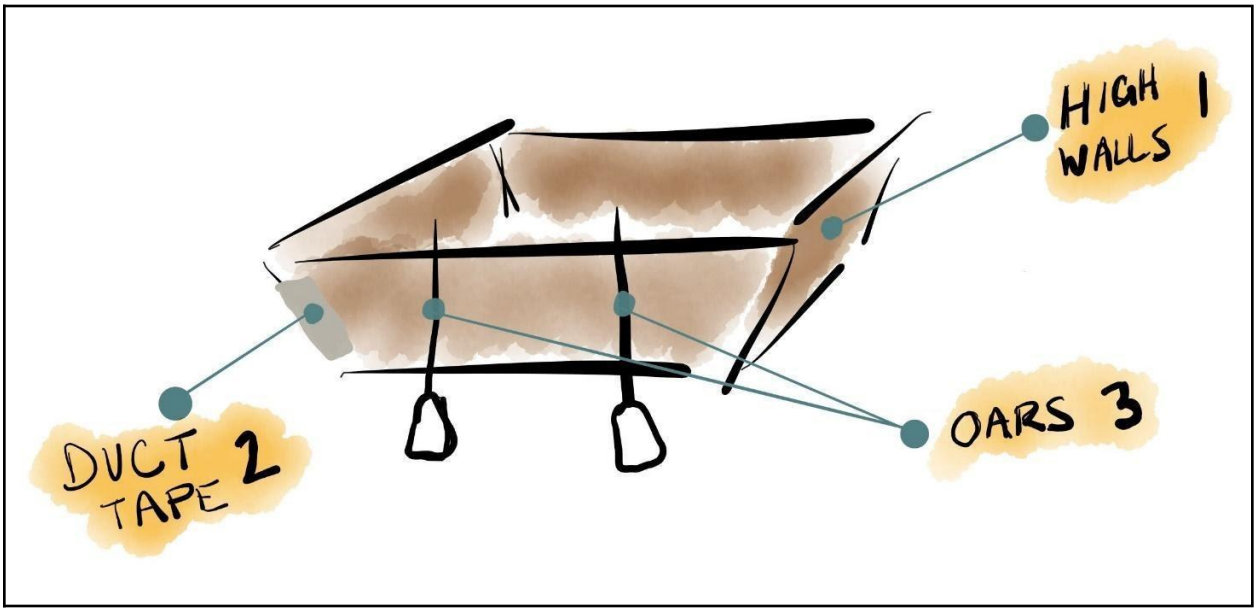
- Advantage, Buoyancy, Consensus, Density, Disadvantage, Experiment, Float(ation), Gallons, Mass, Materials, Observation, Trial, Shipping, Weight, Weight Distribution, Variables, Volume

Assessments and Answer Keys:

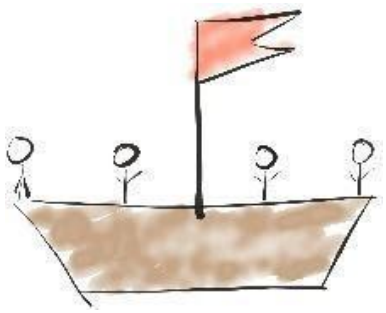
Mini Challenge - Recognize, Recall, & Reflect
Table 1.1 *Sample student responses*

Strategies	Advantages	Disadvantages
I want our team to have the lowest cost bid to make sure the job gets done	More likely to get the bid More likely to be done faster Higher profit margin	Less likely to fulfil the task Less likely to hold during the task Less likely to have enough people to build on time Fewer materials you can buy to build
I want our team to have a higher cost bid and make sure the job gets done the fastest	More likely to fulfil the task More likely to hold during the task More likely to have more people More likely to be done faster More materials you can buy to build	Less likely to get the bid Lower profit margin

Mini Challenge - Think Before You Do
Sample student drawing



Mini Challenge - Observe & Report and Formulate & Create *ANSWER KEYS*		
Material	**Table 1.2 Column C:**	**Table 1.3 Density Rankings**
10 cm x 10 cm square of cardboard	✔	7 (0.69 g/mL)
Ball of tin foil (from a 10 cm x 10 cm sheet)	Varies (loose ✔, tight X)	2 (>2.7 g/mL)
Standard wooden popsicle stick	✔	6 (0.75 g/mL)
Ball of duct tape (from 50 cm length)	✔	5 (0.88-0.96 g/mL)
Penny (or other metal coin)	X	1 (8.96 g/mL)
PVC pipe (5 cm with 1 inch diameter)	✔	4 (0.92 g/mL)
Cardboard with weight (500 mL water bottle)	X	3 (1.11 g/mL)
Note: Densities provided are estimates. We encourage you to calculate the specific densities of the materials used in your STEM Challenge and adjust the keys accordingly.		
Reward: Student groups with 5 or more items ranked in the correct order of density receive an additional 1,000.00 units to their build budgets. Student groups with 4 or less items ranked correctly receive no additional units (0.00 units).		

Design Challenge - Recognize, Recall, & Reflect *ANSWER KEY*	
Students should select the **first boat** with adequate weight distribution. Students' responses may include that without spreading weight apart, the boat may tip, pitch, or experience uneven propulsion.	

Design Challenge - Recognize, Recall, & Reflect **Table 1.4** *Sample student responses*		
Strategies	**Advantages**	**Disadvantages**
Canoe shape?	Hydrodynamic (cuts through water). Fits 1-2 people well.	Cannot hold many people or cargo. Can get flipped over easily.
Canoe stability?	Can stay afloat even when rocked.	Once a canoe is flipped, it is hard to turn back over.
Canoe maneuverability?	It can be manually operated by oars.	It cannot be easily steered without a coxswain (person on the back).

Design Challenge - Think Before You Do *Facilitation Recommendations*
Students should reflect and write about the relationship between design and weight, finding that the canoe is only useful for one or two persons in distributing weight based upon its' canoe shape. Their boat will need to accommodate more people (more weight to distribute) and the shape should maximize the task of moving through the water and turning quickly.

Design Challenge - Design Activity **Table 1.5** *Sample student responses*

Strategies	**Observations** *No Gallons (include time in seconds)*	**Observations** *5 Gallons (include time in seconds)*
Strategy A: Sit facing each other with jugs in middle.	*Responses vary.*	*Responses vary.*
Strategy B: All forward facing with jugs evenly distributed.	*Responses vary.*	*Responses vary.*
Strategy C: Rowers alternate paddling left and right, rather than each rowing on the same side the whole time. Jugs in back of boat.	*Responses vary.*	*Responses vary.*
Note: Students should consider how and where they sit, row, and place the jugs. Facilitate a discussion for these factors as well as the turning ability of the canoe compared to other potential boat shapes. The goal is to determine an efficient build and row strategy for your specific team. Responses to the bar graphs will vary, depending on table 1.5. Consider changing the scale to accommodate actual results.		

Day 2 Overview:

On the second day of the STEM Challenge, students further refine their thinking about how boat materials interact with water and how weight influences the buoyancy of the primary build material: cardboard. They will use their observation skills and mathematics knowledge to calculate how different shapes move through water using ratios. Students establish group norms to begin making their boat designs by determining their roles in the project (i.e., construction engineer, cargo specialist, materials engineer, and communications engineer). From the materials they receive in their base kit (i.e., five large boxes, five medium boxes, one roll of duct tape and four oars), students determine what additional materials they may need within their limited budget.

Objectives:
By the end of the day, students will be able to:

Mini Challenge	**Design Challenge**
• Observe how long it takes for different shapes to float/sink in water. • Discover how the shape of a boat relates to its ability to hold objects and float. • Calculate how weight and shape influence the speed of boats using ratios.	• Assess your interests to determine your role in the building project. • Affirm your group norms. • Design boat within the budget constraints.

	• Outline budget using different prices for objects. • Reconcile your initial boat design to your proposed budget.

Curriculum Connections and Alignment:

- *NGSS*: MS-PS2-2; MS-PS3-5.
  - DCI: PS2.A Forces and Motion
  - CCC: Structure and Function; Cause and Effect
  - SEP: Obtaining, Evaluating, and Communicating Information; Engaging in Argument from Evidence
- *ISTE:*
  - Empowered Learner: 1a. Students articulate and set personal learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process itself to improve learning outcomes.
  - Computational Thinker: 5c. Students break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.
- *CCSS:*
  - ELA Literacy: WHST.6-8.1 (Write arguments focused on discipline content).
  - Mathematics: 6.RP.A.1 (Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities); 7.RP.A.2 (Recognize and represent proportional relationships between quantities).

Teacher/Mentor Actions:
As the Teacher and/or Mentor, you will help support student-directed learning by:

Mini Challenge	Design Challenge
• Support whole-group engagement • Help with pushing the boats • Evaluate the mini challenge winner(s)	• Use student data to assign group roles • Assist students in forming and enforcing group norms • Evaluation and Assessment (Exit Ticket)

Preparation:

Mini Challenge			
Activity Section	Materials Needed (per group)	Time Suggested	Additional Considerations
Recognize, Recall, & Reflect	Printed documents, Pencils, Internet-connected device for watching ***time lapse video***	5-10 minutes	In the experiment used to create the time lapse, the cardboard was fully saturated after 7 days and still did not sink. https://bit.ly/STEMvid1
Think Before you Do	Pencil, Colored Pencils (optional)	10- 15 minutes	Students should consult one another for this activity.

Observe & Report	Setup materials: Standard hard plastic wading pool halfway filled with water, meter sticks, String, stopwatch, tape, handtowels Group materials: 20 marbles, 2 sheets of tin foil measuring 30 cm X 30 cm An additional 30 cm x 30 cm foil sheet	(20 minute teacher set up) 45-60 minutes	The small pool setup can be shared among groups. Schedule rotations to access the pool as needed.
Formulate & Create		10 minutes for individual prediction and calculation 20 minutes for group discussion	Assemble the pool so that time and distance are easily measured. See pictures for an example. The teacher or mentor should be the one that launches each boat design. Remind students to record data after each launch. Note: Design 1 and 2 are for testing purposes. A *new* boat is constructed for the mini challenge competition reward.
Reward: The design that transports the most marbles 60 cm receives an extra roll of duct tape.			
Optional Extension: Give students an opportunity to predict and test the water level change in centimeters (cm) on the wall of the boat before and after adding the 20 marbles. Complete this for both Design 1 and Design 2. Use this information to complete the final mini challenge boat design.			

Design Challenge			
Activity Section	Materials Needed (per group)	Time Suggested	Additional Considerations
Recognize, Recall, & Reflect	Printed documents, pencil	5-10 minutes individually 5-10 minutes as a group	Encourage students to work independently on the interest inventory. Facilitate discussions to elaborate on the interest descriptions. After students have totaled their tables, assign roles to students. These roles are important in Mini Challenge 4. Review norms and elaborate what they look and sound like in your group. Reinforce them throughout the week.
Think Before you Do	Pencil, Colored Pencils (optional) Previous sketches (Day 1 and 2 mini challenges) Optional: Poster Paper or Dry Erase Board	30-45 minutes	Make sure students review their previous work, share equally and compromise on a design by coming to consensus. Ranking allows the students to set priorities if adjustments occur during construction. Optional: Transfer final design to poster paper or dry erase board

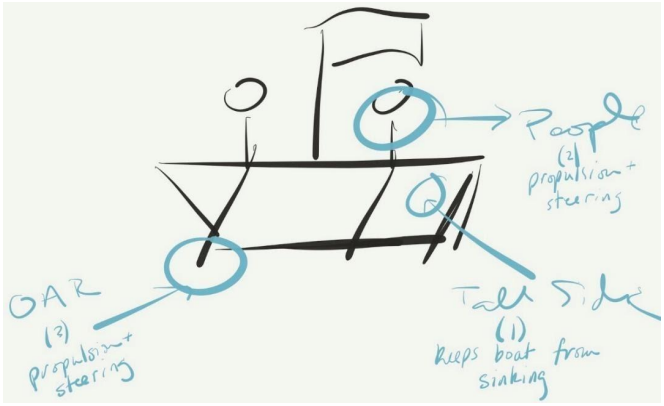
Observe & Report	Cardboard Boxes and Tape (as ordered from the previous purchase order) and Cargo materials (packing, PVC, etc.) Scissors and Box Cutters for builds	30-45 minutes	View samples of materials available to purchase. Facilitate discussion over which materials are helpful or harmful for the group's shipping goals. Remember that efficient use of budget is a part of the final score on Day 5.
Design Activity		30-45 minutes	Allow students to develop their purchase order. Verify they do not exceed 6000 units unless they received a bonus from Day 1.
Exit Ticket	Pencil	5 minutes	Collect or review exit tickets to plan the next day's activities.
Note: Many groups find making a small-scale model of their final design helpful in identifying construction obstacles. If teams have extra time, this is highly recommended.			

Target Vocabulary:

- Assessment, Distance, Float, Maneuverability, Prediction, Ratios, Rowing, Sink, Speed, Weight, Water Dynamics, Water Level

Assessments and Answer Keys:

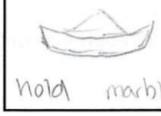
Mini Challenge - Recognize, Recall, & Reflect *Facilitation Recommendations*
Students should note the cardboard does not sink easily. Descriptions could include observations about saturation, density, shape of the cardboard, etc.

Mini Challenge - Think Before You Do *Sample student drawing*


Mini Challenge - Observe & Report

Table 2.1 *Sample student response*

Table 2.1 *Boat movement in the water*

Draw shape of boat designs. Design 1  Design 2 	**Predict Column A:** How far do you think your boat will go in cm?	**Predict/ Record: Column B:** *Predict*: Will it float with 20 marbles? *Record*: Did it?	**Record: Column C:** How far did the boat go before it stopped?	**Record: Column D:** How many seconds until it stopped?	**Calculate: Column E:** Calculate the speed (distance / time)?
Design 1 (without marbles):	60cm		50cm	20.59	2.43
Design 1 (with marbles):	60cm	P: (yes) / no R: (yes) / no	50 cm	1.52	32.9
Design 2 (without marbles):	50cm		50cm	4.53	11.04
Design 2 (with marbles):	50cm	P: (yes) / no R: yes / no	50cm	.76	65.789

cm per sec

Mini Challenge - Observe & Report
Table 2.2 *Sample student response*

Table 2.2 Benefits and Drawbacks in Boat Design

	For Weight Distribution		For Water Resistance	
	Benefit	**Drawback**	**Benefit**	**Drawback**
Design 1: (without marbles)	• Stays afloat due to air pocket.	• Slower speed	• Pointy tip push through the water.	• Had more volume • Slower
Design 1: (with marbles)	• Weight distribution	N/A	Same	• Rounder shape made boat spin.
Design 2: (without marbles)	• Hull helped balance weight distribution & go straight.	N/A	• Hull cut through water.	• Hull wasn't centered
Design 2: (with marbles)	Same	N/A	Same	Same

Day 3 Overview:

On the third day of the STEM Challenge, students learn about the concepts of crush and tilt as it relates to securing cargo and ensuring its safe delivery. They will use their engineering design skills to develop and test prototypes for crush and tilt factors. Students build upon these experiences by incorporating a cargo design, into their extant boat design, by selecting different materials for the cargo build within their limited budget. At the end of this day, students begin their boat builds.

Objectives:
By the end of the day, students will be able to:

Mini Challenge	Design Challenge
• Discuss the concepts of crush and tilt and how these can damage a ship's cargo. • Design and construct a cargo container for a safe delivery of cargo. • Develop a prototype for a cargo container. • Measure the efficacy of your prototype using crush and tilt factors.	• Reflect on the important scientific elements of the preliminary boat design. • Consider new structural elements (e.g., cardboard and tape) for your cargo container design. • Explore different prices for objects (constraint of budget) for your cargo container design. • Build and create your own tilt sensor. • Begin your boat builds, cargo container builds and tilt sensors using your group boat design.

Curriculum Connections and Alignment:

- *NGSS*: MS-ETS-1.1; MS-ETS-1.2; MS-ETS-1.3; MS-ETS-1.4.
    - DCI: ETS1.A Defining and Delimiting Engineering Problems; ETS1.B Developing Possible Solutions; ETS1.C Optimizing the Design Solution
    - CCC: Influence of Science, Engineering, and Technology on Society and the Natural World
    - SEP: Developing and Using Models; Analyzing and Interpreting Data
- *ISTE:*
    - Innovative Designer: 4c. Students develop, test and refine prototypes as part of a cyclical design process.
    - Computational Thinker: 5c. Students break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.
- *CCSS:*
    - ELA Literacy: RST.6.-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
    - Mathematics: MP.2.7EE.2 (Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically; MP.2.7.EE.3 (Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies); and MP.2.7.SP (Develop a probability model and use it to find probabilities of events.

Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy).

Teacher/Mentor Actions:
As the Teacher and/or Mentor, you will help support student-directed learning by:

Mini Challenge	Design Challenge
• Support whole-group engagement • Provide more information on key vocabulary terms (e.g., crush, tilt) • Clarify and conduct prototype testing • Evaluate the mini challenge winner(s) • Make sure boat materials are ready for building at the end of the design challenge	• Reviews purchase orders and gathers materials for the next day • Monitor students for a safe build • Evaluation and Assessment (Exit Ticket)

Preparation:

Mini Challenge			
Activity Section	Materials Needed (per group)	Time Suggested	Additional Considerations
Recognize, Recall, & Reflect	Printed Documents, Pencils	5 minutes	You can learn more about cargo delivery systems at this link and this link.
Think Before you Do	Pencil, Colored Pencils (optional)	10 minutes	Consider items in real life that help with tilt and crush prevention. Students brainstorm independently for Table 3.1.
Observe & Report		20 minutes	Clarify the concept of prototyping if need be. Ensure that students are designing *packages* for the egg container, not adding anything inside the container.
Formulate & Create	Cargo Materials (i.e., Packing Material, Packing Peanuts, Bubble Wrap, Box Larger than Egg Container) Meter Stick Two Eggs, Sealable Plastic Cargo Container Shake Table (e.g., Marbles Inside a Cardboard Box that	45 minutes	You may need to provide students additional information about crush and tilt, found here. Conduct the prototype testing to ensure parity in stress testing. You may wish to have half the students conducting the tilt test and the other half the crush test (and then switch). • Tilt – 20 seconds in the shake table • Crush – dropping the egg from 1 meter above the ground Use rubric in student sheets to determine the mini challenge winners.

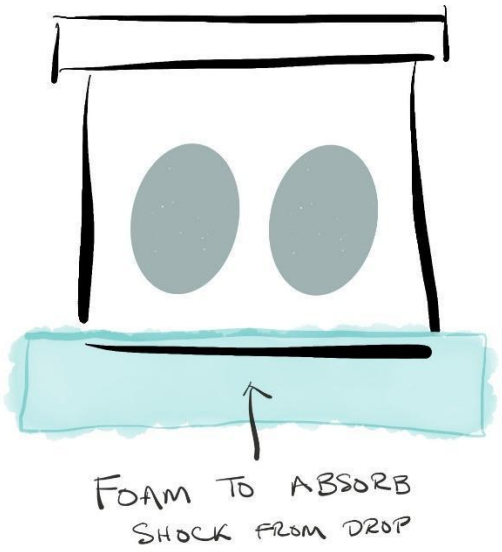
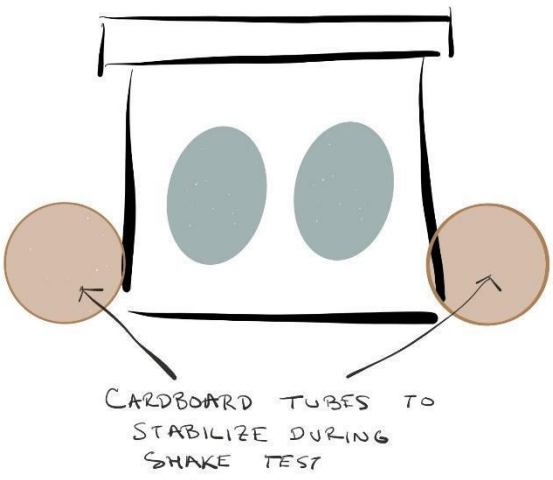
	the cargo container will be put on and shaken on)		

Design Challenge			
Activity Section	Materials Needed (per group)	Time Suggested	Additional Considerations
Recognize, Recall, & Reflect	Printed documents, Pencil, Boat Base Kit Supplies, Scissors, Box Cutters, Permanent Markers	5 minutes	Students may need help defining terms and what constitutes a strength or concern in their boat design from Day 2 Design Challenge.
Think Before you Do		10 minutes	This is your final design process before beginning to build. Have each student speak from their role about design changes that may need to be made. Confirm that each team member has an idea reflected in the final design. Discuss the boat's ability to successfully traverse the pool, hold weight, and be expedient.
Observe & Report		15 minutes	Ensure that students work through the activity individually and then collectively. Collect students' purchase orders to verify the budget (costs) and procure the requested materials for the next day's activities. You can vary the amount of additional units given (2,000) to vary the difficulty, as long as this is done across the board. You can also change prices or availability of products to reflect fluctuations in "market demands".
Design Activity		Remainder of Time (3 to 4 hours)	Teams should begin building tip sensors and/or their boats after submitting their final purchase orders. Some teams may want to divide students to simultaneously work on both projects. Tip sensor activity can be adjusted to either slow teams down and ensure they do not complete their boats too quickly or have a minimal impact on team bandwidth. You can simplify the challenge by pre-fabricating or purchasing sensors and just providing them to each team. Monitor students and help them cut boxes (box cutters). Having safety guidelines or rules in effect is a good idea before beginning to build.
Exit Ticket	Pencils	5 minutes	Collect or review exit tickets to plan the next day's activities.

Target Vocabulary:

- Buoyancy, Cargo, Crush, Damage, Damage, Dangerous, Durability, Fragile, Maneuverability, Propulsion, Prototype, Shape, Speed, Stability, Surface Area, Team Coordination, Tilt, Weight Distribution

Assessments and Answer Keys:

Mini Challenge - Think Before You Do ***Table 3.1* Sample Student Responses**	
CRUSH	***TILT***
	

Mini Challenge - Formulate & Create ***Table 3.2* Sample Student Responses**		
Test Results	**Measured Crush Damage** (Heavy, Moderate, Light, or None)	**Measured Tilt Damage** (Heavy, Moderate, Light, or None)
My Team Prototype	Should report one of the four options.	Should report one of the four options.

Mini Challenge - Formulate & Create ***Table 3.3* Sample Student Responses**				
Assessment of Prototype	**For Crush**		**For Tilt**	
	Benefit	**Drawback**	**Benefit**	**Drawback**

Group Prototype	Certain materials were better for protecting the eggs, reducing the amount of air between eggs and material was best to reduce crush.	Certain materials better for protecting eggs were not easy to work with, more expensive, etc.	Certain shapes of designs (boxy) were better than others (sphere). Some materials helped keep the shape to reduce tilting.	Certain prototypes may need a team member to hold them to prevent tipping in the STEM Challenge.
Reward: Student groups with the least amount of Crush and Tilt damage (either none or light in both categories) to their prototypes win. Winners receive a free packet of bubble wrap for their cargo builds.				

Design Challenge - Think Before You Do *Facilitation Recommendations*
Students should share two ideas, preferably one a strength and one as a concern. They should identify which of the 10 concerns listed can be addressed in the design phase. They may note aspects of the boat design that relate centrally to the challenge with is working together (Team coordination), keeping afloat (Buoyancy, Stability, Surface Area/Weight Distribution), not sinking (Durability), getting across the pool (Propulsion, Maneuverability, Shape, Speed) with the boat intact (Damage).

Day 4 Overview:

On the fourth day of the STEM Challenge, students consider the means of cargo transport and its role in the STEM Challenge. They will use their engineering design skills to incorporate cargo elements into their boat designs. Teams develop presentations of three engineering concepts they have incorporated into their build. Students continue their boat and cargo builds on this day and need to finish by the end of the day.

Objectives:
By the end of the day, students will be able to:

Mini Challenge	Design Challenge
• Observe different strategies to move cargo across the United States. • Explore strategies, within your design, that best ferry cargo across the pool. • Develop a presentation to defend your strategies to be successful in the STEM Challenge.	• Assess your group's progress towards the goals of the STEM Challenge. • Explore different prices for objects (constraint of budget) for the cargo container. • Consider what monies are remaining in the budget that can increase your profit (Math Connection). • Continue building your boat and cargo container from the group designs.

Curriculum Connections and Alignment:

- *NGSS*: MS-ETS-1.1; MS-ETS-1.2; MS-ETS-1.3; MS-ETS-1.4.

  - DCI: ETS 1.A Defining and Delimiting Engineering Problems; ETS1.B Developing Possible Solutions; ETS1.C Optimizing the Design Solution
  - CCC: Influence of Science, Engineering, and Technology on Society and the Natural World
  - SEP: Engaging in Argument from Evidence; Analyzing and Interpreting Data
- *ISTE:*
  - Creative Communicator. 6c. Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.
  - Creative Communicator. 6d. Students publish or present content that customizes the message and medium for their intended audiences.
- *CCSS:*
  - ELA Literacy: SL8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
  - Mathematics: MP.2.7SP Reason abstractly and quantitatively.

Teacher/Mentor Actions:
As the Teacher and/or Mentor, you will help support student-directed learning by:

Mini Challenge	Design Challenge
• Support whole-group engagement • Provide informational support on balance and counterbalance • Evaluate the mini challenge winner(s)	• Help cut boxes (with scissors and box cutters) • Assist with procuring build materials • Evaluation and Assessment (Exit Ticket)

Preparation:

Mini Challenge			
Activity Section	Materials Needed (per group)	Time Suggested	Additional Considerations
Recognize, Recall, & Reflect	Printed Documents, Pencil, Colored Pencils (optional)	5 minutes	Ensure students understand the concepts of balance and counterbalance as they develop their thinking.
Think Before you Do		10 minutes	
Observe & Report		15 minutes	
Formulate & Create	Computers or Tablets (if using Google Slides) Pencils and Colored Pencils (if using paper storyboards by printing out the slides) VIP judges	60 minutes	Remind students that their pitches should include the three attributes and will be rubric scored by the elements on the slide. You can print out three slides per group to avoid technology use.
Design Challenge			

Activity Section	Materials Needed (per group)	Time Suggested	Additional Considerations
Recognize, Recall, & Reflect	Pencil	5 minutes	While students are discussing, make sure the boat and cargo building materials are ready for the builds.
Think Before you Do		10 minutes	
Observe & Report		15 minutes	
Design Activity	Cardboard Boxes and Tape (as ordered from the previous purchase order) and Cargo materials (packing, PVC, etc.) Scissors and Box Cutters for builds	Remainder of Time (3-4 hours)	Monitor students and help them cut boxes (box cutters). Consider how to move boat and cargo builds carefully to the racing center for Day 5. If students finish early, have them design a team flag or logo that should be included on their boat. They can decorate their boats to promote their shipping company or school.
Exit Ticket	Pencil	5 minutes	Collect or review exit tickets to plan the next day's activities.

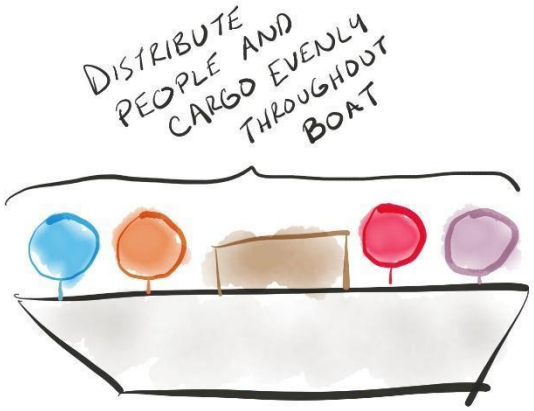
Target Vocabulary:

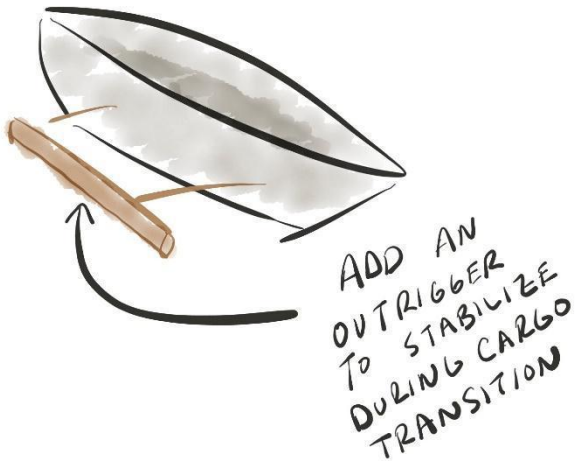
- Airplane, Balance, Barge, Buoyancy, Cargo, Counterbalance, Damage, Durability, Maneuverability, Propulsion, Shape, Shipment, Speed, Stability, Surface Area, Team Coordination, Truck, Weight Distribution

Assessments and Answer Keys:

Mini Challenge - Recognize, Recall, & Reflect *Facilitation Recommendations*
Students' answers may vary, but should describe that **airplanes** can hold a decent amount of cargo (of only of a certain weight), but can travel very fast and across all types of terrain; **barges** can hold a lot of cargo (and of all weights), but can only travel slowly and where there is water access; and **trucks** can hold just a little bit of cargo (of only a certain weight), but can travel faster than barges, but only over land terrain.

Mini Challenge - Think Before You Do ***Table 4.1*** *Sample Student Responses*	
BALANCE taking on NEW CARGO	***COUNTERBALANCE taking on NEW CARGO***





Note: Observe and Report section will include an idea that has reached consensus for the team. These sketches may vary, but students should consider both counterbalance and balance.

Mini Challenge - Formulate & Create *Scoring Rubric for Guest Judges*				
Attribute (Should be Three)	**Not Proficient (0 Points)**	**Approaches Proficiency (1 Point)**	**Meets Proficiency (3 Points)**	**Exceeds Proficiency (5 Points)**
Students should select three of the following: • Stability • Speed • Maneuverability • Propulsion • Cargo • Watertightness • Structural Integrity • Technique	Does not correctly identify or define the attribute. Does not correctly describe how the attribute is incorporated into the design. Makes no reference to student's jobs in the presentation.	Identifies the attribute but only partially defines the attribute. Indirectly describes how the attribute chosen is incorporated into the design. Makes vague reference to student's jobs in the presentation (e.g., how they are going to carry eggs strategy #1).	Identifies the attribute and correctly defines the attribute. Directly describes how the attribute chosen is incorporated into the design. Makes some reference to student's jobs in the presentation (e.g., what the cargo's relationship is strategy #1).	Identifies the attribute and correctly defines the attribute, using scientific language and/or graphics for the viewer. Directly describes how the attribute chosen is incorporated into the design with exemplars of design. Makes explicit reference to student's jobs in the presentation (e.g., what the cargo designer's ideas for strategy #1).
Note: This rubric should be used three times for each team. One per strategy per team.				
Reward: Student groups with the highest numerical rubric score win. Winners receive a bonus to their profit of 2500 for first place, 1500 for second place, and 500 for third place.				

Day 5 Overview:

On the fifth and final day of the STEM Challenge, students reflect on their work and roles in developing the boat and cargo designs and builds in the STEM Challenge overall. They will use their observation skills to review best practices of other groups in their boat and/or cargo builds. Students test their boat and cargo builds on this day. Student groups are ranked on their performance on the Challenge Rubric.

Objectives:
By the end of the day, students will be able to:

Mini Challenge	Design Challenge
• Reflect on how your job in the group contributed to the final boat and cargo build. • Consult with your teammates on other contributions you made to the final boat and cargo build. • Consider how other groups creatively made their final builds. • Communicate with community members and convince them that your team's build is the best.	• Review the rules for a fair STEM Challenge Contest. • Race your builds across the water by exchanging your cargo and rowing back to the original port. • Calculate the "winner" of the STEM Challenge Event.

Curriculum Connections and Alignment:

- *NGSS*: MS-ETS-1.1; MS-ETS-1.2; MS-ETS-1.3; MS-ETS-1.4.
    - DCI: ETS 1.A Defining and Delimiting Engineering Problems; ETS1.B Developing Possible Solutions; ETS1.C Optimizing the Design Solution
    - CCC: Patterns
    - SEP: Obtaining, Evaluating, and Communicating Information
- *ISTE:*
    - Empowered Learner: 1a. Students articulate and set personal learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process itself to improve learning outcomes.
    - Innovative Designer: 4d. Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.
- *CCSS:*
    - ELA Literacy: SL 8.5 (Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest).
    - Mathematics: MP.2.7EE.2 (Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically), MP.2.7.EE.3 (Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies).

Teacher/Mentor Actions:
As the Teacher and/or Mentor, you will help support student-directed learning by:

Mini Challenge	Design Challenge

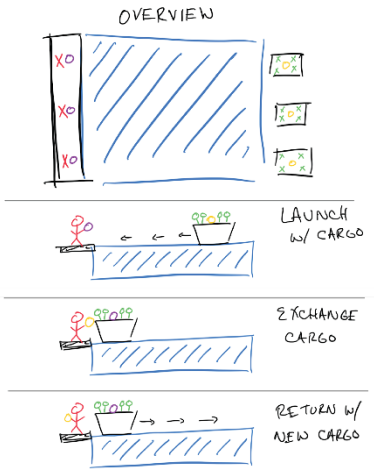
• Support whole-group engagement • Provide guiding questions • Help groups develop presentations • Evaluate the mini challenge winner(s)	• Assist with pool safety • Receive the cargo during the race • Calculate ranks of group performance in the STEM Challenge • Evaluation and Assessment (Exit Ticket)

Preparation:

<table>
<tr><th colspan="4">Mini Challenge</th></tr>
<tr><th>Activity Section</th><th>Materials Needed</th><th>Time Suggested</th><th>Additional Considerations</th></tr>
<tr><td>Recognize, Recall, & Reflect</td><td rowspan="3">Printed Documents, Pencils, Clipboards (recommended)

Boats and cargo containers on a dry surface near the pool. This space should be large enough for the students to stand near their boats while others walk around them.

2 Gallons jugs of sealed water (taped together) per racing group, Tilt sensors attached to water jugs, Heat or race order if necessary

VIP judges</td><td>5 minutes</td><td rowspan="2">Teacher Prep: Make sure boats and cargo (sealable cargo containers with 2 raw eggs) are at the starting lines and new cargo (2 gallon jugs) are waiting for groups at the port (halfway point where eggs and water are exchanged during the race).
 
</td></tr>
<tr><td>Think Before you Do</td><td>5 minutes</td></tr>
<tr><td>Observe & Report</td><td>20 minutes</td><td>Allow students to examine both their boat and cargo builds for any structural damage in transport.

This is the time for students to view the other boats and cargo containers that are part of the STEM Challenge.

Have students compare and contrast their boat designs and cargo containers with other groups.</td></tr>
<tr><td>Formulate & Create</td><td>Boat and Cargo Designs (Sketches)
Boat and Cargo Builds, Judges, Lifeguards,</td><td>60 minutes</td><td>You may wish to invite “VIPs” to this event to act as judges. You can also record students’ pitches and post online as a means to promote your event.</td></tr>
</table>

	Timekeepers, stopwatches		Each team should be able to talk to the public attending the event about what makes their boat and shipping company special.

Design Challenge			
Activity Section	Materials Needed (per group)	Time Suggested	Additional Considerations
STEM Challenge	Boat and Cargo Builds, Computer or Table with the payment calculator	~15 minutes per race *Example*: 12 teams with 3 teams per heat would be 60-90 minutes	Make sure students are clear on the rules of the event. Make sure to provide assistance to students who may need help in the water. Calculate the Winning team and ranks of teams using the payment calculator. Note that Day 4 and 5 mini-challenge winners will need to have their prizes incorporated into the final tally on the Challenge Rubric spreadsheet. This day is all about fun! Consider a celebratory lunch, giving out t-shirts or prizes and having an awards ceremony to celebrate the winners.
Exit Ticket	Pencil	5 minutes	Collect or review exit tickets to plan the next day's activities.
Optional Extension: You can offer an additional complication to teams by allowing them to purchase shipment insurance from their remaining funds. The			

Target Vocabulary: None

Assessments and Answer Keys:

Mini Challenge - Recognize, Recall, & Reflect *Facilitation Recommendations*
Should students struggle in thinking through their contribution, please use the following prompts: 1. Who helped decide the shape of your boat? 2. Who helped determine how will your boat float on the water? 3. Who helped test what floats your boat? 4. Who helped in making your boat move? 5. Who helped to decide how many people do you need in your boat and for what tasks? 6. Who helped determine how your boat will turn? 7. Who helped in deciding how to power your boat? 8. Who helped figuring out how to keep water out of your boat?

9. Who helped in making sure your boat won't flip over?
10. Who helped in ensuring the cargo's safety?

Mini Challenge - Formulate & Create *Scoring Rubric for Guest Judges*				
Attributes	**Not Proficient (0 Points)**	**Approaches Proficiency (1 Point)**	**Meets Proficiency (3 Points)**	**Exceeds Proficiency (5 Points)**
Each team member can talk to a specific **contribution** they made [professional]	Not mentioned	Only one team member mentions their contribution.	All team members mention their contribution.	All team members describe their contributions.
To talk about the **boat** design and how the design guided the build [engineering design]	Not mentioned	The team only describes the boat build and not the design.	The team describes how they went from boat design to build.	The team describes, in detail, how they went from boat design to build.
To talk about the **cargo** design and how the design guided the build [engineering design]	Not mentioned	The team only describes the cargo build and not the design.	The team describes how they went from cargo design to build.	The team describes, in detail, how they went from cargo design to build.
To describe how your team will work together for **safety** [safety]	Not mentioned	Safety is mentioned in name only, but nothing specific.	Basic safety is mentioned (e.g., not falling out)	Advanced safety is described as part and parcel of boat design and build.
To describe how your team will work together for **efficiency** [teamwork]	Not mentioned	Efficiency is mentioned in name only, but nothing specific.	Basic efficiency **is** mentioned (e.g., we will row the boat)	Advanced efficiency is described as part and parcel of boat design and build.
To describe how your team was **creative** in their design [creativity]	Not mentioned	Creativity is mentioned in name only, but nothing specific.	Creativity is mentioned (e.g., we will row the boat)	Creative design is described as part and parcel of boat design and build.
Note: Score each of the five attributes on the scale of 5, 3, 1, or 0 for each group. Sum the five attributes to obtain the group's total score.				
Reward: Winners receive a time bonus added to their overall score in the STEM Challenge: a reduction in race time of 5 seconds for first place, 3 seconds for second place and 1 second for third place.				

Mini Challenge - Formulate & Create ***Table 5.1*** *Optional Superlative Rubric for Participants or Guests*			
Write in for the team you believe is the best in each category (you may leave some categories blank).			
Most Professional		Safest	
Best Boat Design		Best Teamwork	
Best Cargo Design		Write-in Award: _____	
Most Creative			

Note: You may use this ballot to collect information from the crowd to determine superlative winners, which can be announced after the STEM Challenge has completed.

Design Challenge - THE STEM CHALLENGE
Facilitation Recommendations

Calculate the Winning team and ranks of teams using the payment calculator. Students should record their results in Table 5.1. Announce winners of the other superlatives when discussing the winners.